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Implementation of PC-Based Project Management in an Integrated Planning Process

VIIA-2

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National Steel and Shipbuilding Co.

ABSTRACT

This paper describes the progress made and lessons learned by National Steel and Shipbuilding (NASSCO) on National Ship Research Program (NSRP) task N8-91-6 "Implementation of PC-Based Project Management in an Integrated Planning Process." NASSCO is developing a computer-based model which will serve as a tool to assist planning organizations in developing, updating, and revising Master Production Schedules (MPS) as well as manning and facility utilization reports.

GLOSSARY

The following definitions are provided to clarify usage within this paper. They are not meant to imply any type of industry standard.

MASTER PRODUCTION SCHEDULE (as defined by the American Production and Inventory Control Society Dictionary)"... the anticipated build schedule for those selected items assigned to the master scheduler..." [l]

BLOCK- A structural assembly which will be erected singly or as part of a grand block

GRAND BLOCK- Two or more blocks that have been joined into a single unit prior to erection.

LONG RANGE FORECAST- Needs implied by schedules over a two to three year time span. This forecast will show manning and capacity needs of a project from start of construction to launch.

SHORT TERM REQUIREMENTS- Needs implied by schedules over a two to three month time span. The requirements are used for regularly updated, detailed manpower and facility utilization planning.

SYSTEM DEVELOPMENT PHILOSOPHY

The purpose of scheduling is to optimize the use of resources so that the overall production objectives are met. Scheduling involves the assignment of dates to specific tasks. Machine breakdowns, absenteeism, quality and performance problems, material shortages, and other factors complicate the manufacturing environment. Hence, the assignment of a date does not ensure that the work will be performed at that time. [2] A scheduling system should have the ability to adapt schedules to reflect changes in the manufacturing environment.

An effective model for use in production scheduling must reflect the strategy by which the ship will be built. These strategies establish the activity durations, resource utilization, and relationships to be used by the Integrated Production Planning System. The system models discussed in this paper are based upon the strategy sheets described in table 1. (Note: these strategy sheets are illustrated in the System's Usage section of this paper.) All strategy sheets are reviewed, discussed, and approved prior to model development.

Even if a PC-based model of the production process was not developed, creation of the documents described above is a useful tool. By bringing together the various production and support groups for the strategy review process, the build strategies will often be substantially improved.

In addition to the strategy sheets, it is also necessary to develop a coding system for the work breakdown structure (WBS) and the organizational breakdown structure (OBS). Development of these coding systems allows the data to be grouped in meaningful ways. Schedule information is distributed to all required groups in a format meaningful to that group.

A schedule dictates not only the dates on which various activities occur, but also a specific set of material, engineering, facility utilization, and manning requirements. For a schedule to remain credible, it must account for actual material delivery, engineering drawing issues, facility availability, and manpower availability. This cyclic relationship implies that a credible schedule can be derived only when these factors are considered together.

STRATEGY SHEET	DESCRIPTION
BLOCK BREAKDOWN DIAGRAM	IDENTIFIES BREAKDOWN OF SHIP INTO STRUCTURAL ASSEMBLIES AND SHOWS ASSEMBLIES THAT JOIN TOGETHER PRIOR TO ERECTION.
STRATEGY, DURATION, AND RESOURCE REQUIREMENTS BY BLOCK TYPE	GROUPS BLOCKS INTO SIMILAR TYPES. STRATEGIES, ACTIVITY DURATIONS, AND ACTIVITY RESOURCE REQUIREMENTS ARE GIVEN FOR EACH BLOCK TYPE.
BUILD STRATEGY SHEETS	SHOWS ACTIVITIES TO BE TRACKED BY THE INTEGRATED PRODUCTION PLANNING SYSTEM AND THE RELATIONSHIPS BETWEEN THESE ACTIVITIES FOR EACH BUILD STRATEGY.
ERECTION 'STAR' CHART	SHOWS THE DATE EACH ERECTABLE UNIT IS SCHEDULED TO BE JOINED TO THE SHIP.
GRAND BLOCK STRATEGY SHEETS	SHOWS IN GANTT CHART FORMAT THE STRATEGY BY WHICH THE BLOCKS WILL OUTFIT AND STACK TO GETHER TO FORM THE GRAND BLOCK.
PROCESS LANE STRATEGY SHEETS	SHOWS IN GANTT CHART FORMAT THE FLOW OF BLOCKS THROUGH EACH OF THE DEDICATED PROCESS LANES.

Table 1: Strategy sheet descriptions.

Data are facts concerning objects, events, relationships, and requirements. Information is data that have been organized in a form that is suitable for decision making. The development of a schedule in not an analytically complex task Development is made complex due to the large volume of data which must be considered when developing schedules. The Integrated Production Planning System transforms the large volume of data which influences schedules into information. The clearest way to convey this information is through graphical displays of schedules, manning and facility utilization data. By showing relevant data in this graphical form, the system should serve as a useful tool in generating and updating the MPS.

SCOPE OF PROJECT

An effective integrated production schedule must consider all activities that go on within a shipyard. However, this does not mean that a single production planning system must model all activities. If an individual system models a well-defined area of the shipyard, this information can be combined with information regarding other areas to develop an overall view of de shipyard system.

The scope of activities to be modeled by the Integrated Production Planning System are listed.

Fabrication of Steel Parts
Block Sub-Assemblies (i.e. building of bulkheads and decks from fabricated parts)
Block Assembly
Pre-Blast Outfitting of Blocks
Blast and Paint of Blocks
Post-Blast Outfitting of Blocks
Grand Blocking (joining of blocks before they erect to ship)
Block or Grand Block Erection to Ship

The on-board, shop, production service, repair, and non-production activities are not modeled by this system. Schedules and information regarding these activities are developed in parallel with the system. This data is combined with the data developed by the Integrated Production Planning System and is used to provide information regarding the entire shipyard.

The MPS must be coupled to bills of material structured to support the production process. They are not separate issues. A workable interface between the scheduling and material requirement system is vital. Development of this interface is dependent upon both the planning and material systems employed by the yard.

This issue will not be addressed in this paper. However, when an integrated production scheduling system is being developed, the scheduling/materials system interface must be considered.

As with the bills of material, the MPS must be supported by engineering. Engineering specifications and drawings must be scheduled so as to be completed in support of the production and material ordering process. However, the scheduling of these items will not be considered within the scope of this project

SCHEDULE GENERATION SYSTEM OVERVIEW

The flow chart below shows the Integrated Production Planning System's major inputs, outputs, and components. The system consists of four modules which interact to create both the baseline and regularly updated production schedules. The system also generates manning and facility long range and short term requirements.

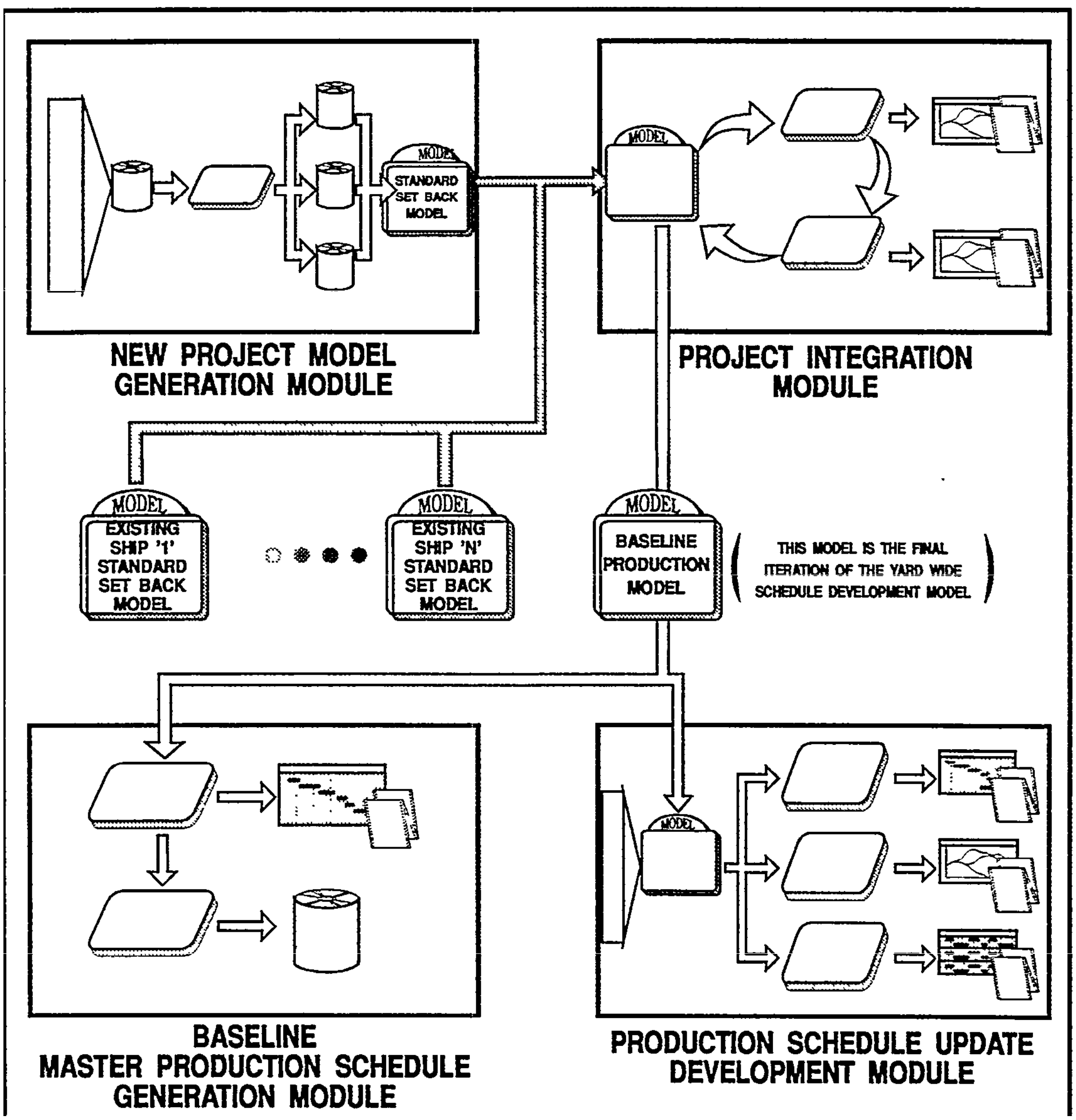


Figure 1 : Intrgrated Production Planning System Flowchart.

The new project model generation module is shown in figure 2. When a new project (i.e., a ship) is brought into the yard, data is gathered regarding build strategies, activity resource requirements, process lane considerations, and block erection data. All this information is integrated into a Ship Build Master Data File. This data is passed through the Model Builder Program which creates a Standard Set Back Model for de ship.

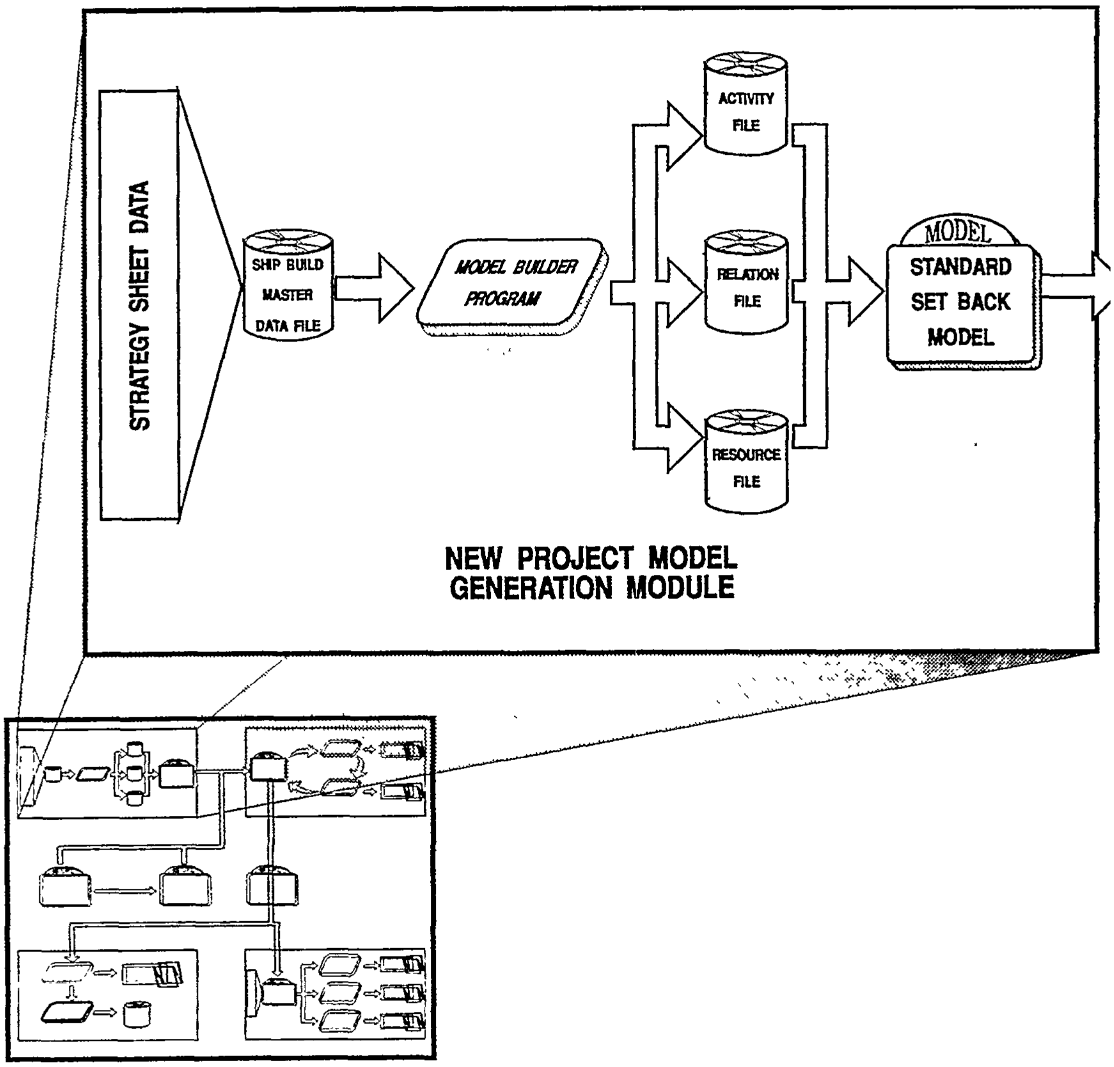


Figure 2 : New Project Model Generation Module.

The project integration module is shown in figure 3. Standard set back models take into account build strategies for only the individual ship. Since all ships are built with common facilities and manpower, leveling the MPS is done with all the projects in the yard considered together. The Standard Set Back Model is combined with the standard set back models of previously scheduled work to create a Yardwide Schedule Development Model. This model is processed to show the capacity and manpower requirements implied by these schedules. Based upon this information, the model is refined through an iterative process. Capacities and manning implied by the schedule are investigated. Schedules are modified until acceptable capacity utilization and manning are achieved. The final iteration of the model is reviewed and approved by the various department heads. Upon approval, this model becomes the Baseline Production Model.

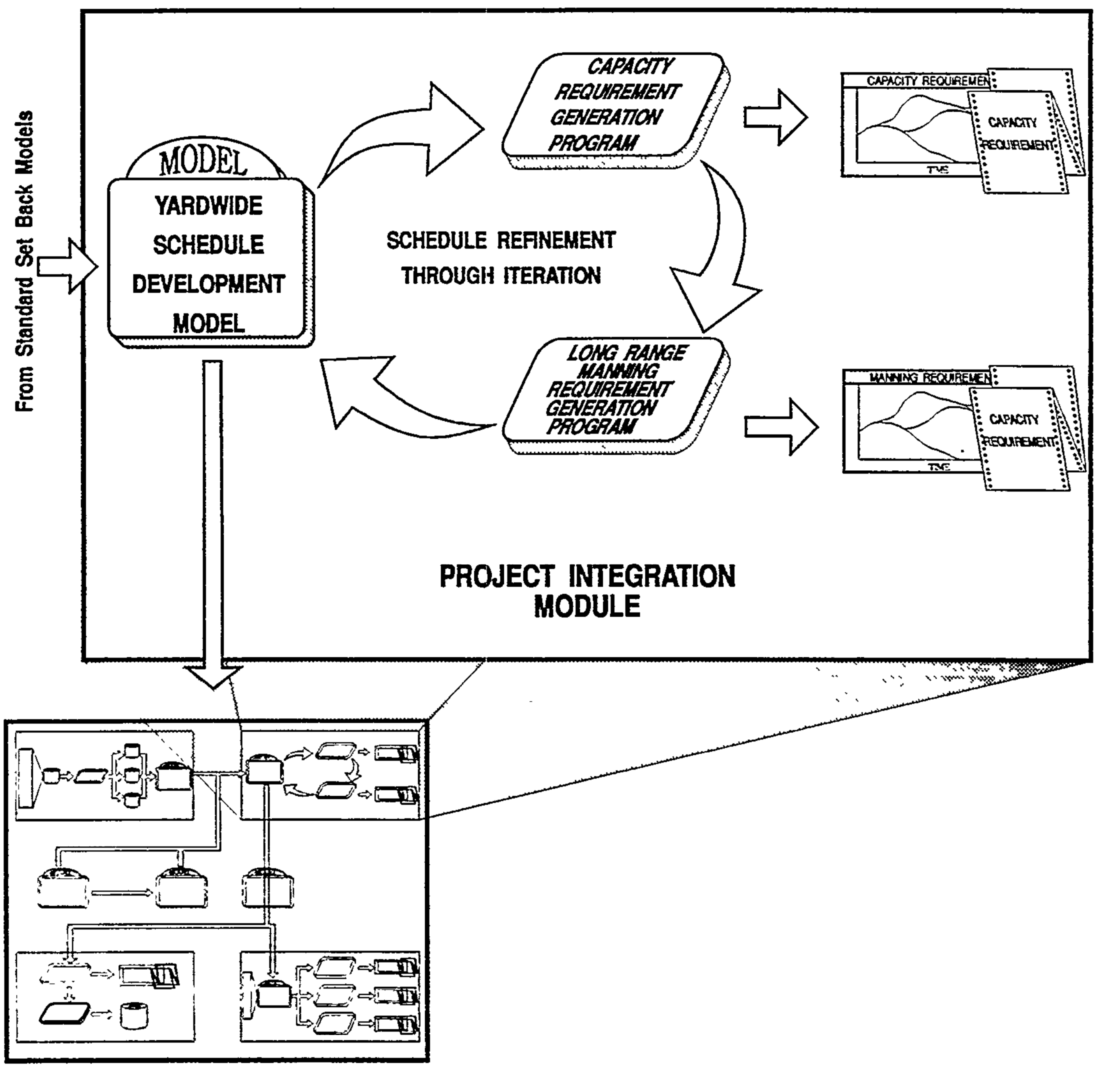


Figure 3 : Project Integration Module.

The baseline master production schedule generation model is shown in figure 4. The Baseline Production Model is used to create and update the master production schedules for each project. The model is also used to create and update a database which serves as the baseline schedule for the schedule tracking system. The Baseline Production Model is altered only when a new revision of an existing project's schedule is issued.

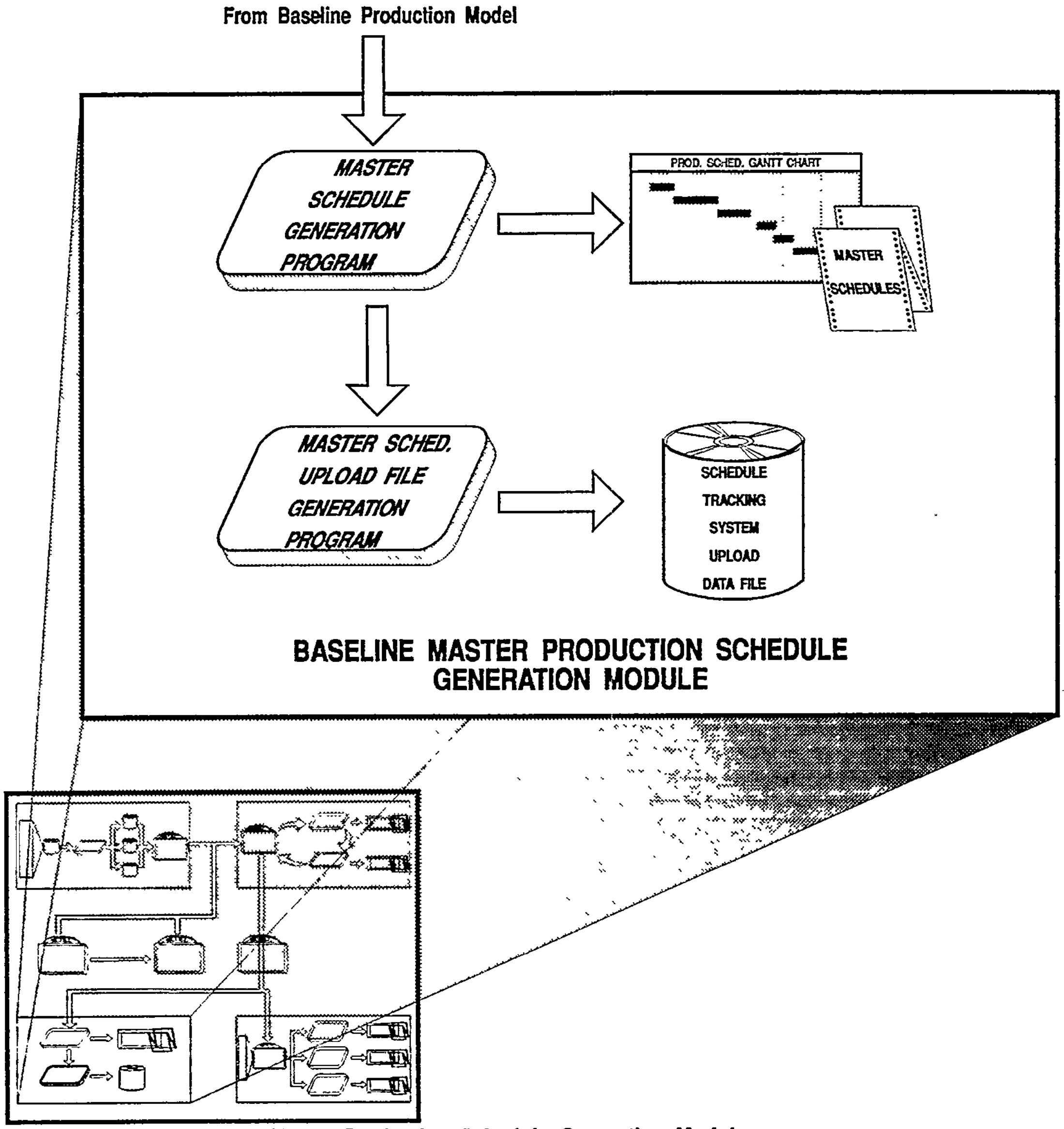


Figure 4 : Baseline Master Production Schedule Generation Module.

The production schedule update development module is shown in figure 5. A copy of the Baseline Production Model is renamed the Production Update Model. This model is updated based on weekly meetings and progress data. The updated model is processed and used to generate regularly issued production schedules, manning curves, and facility utilization reports (laydown schedules). The production schedules show planned vs. actual and projected progress. The manning curves and facility utilization reports reflect adjustments that have been made from de master schedule to the current production schedule.

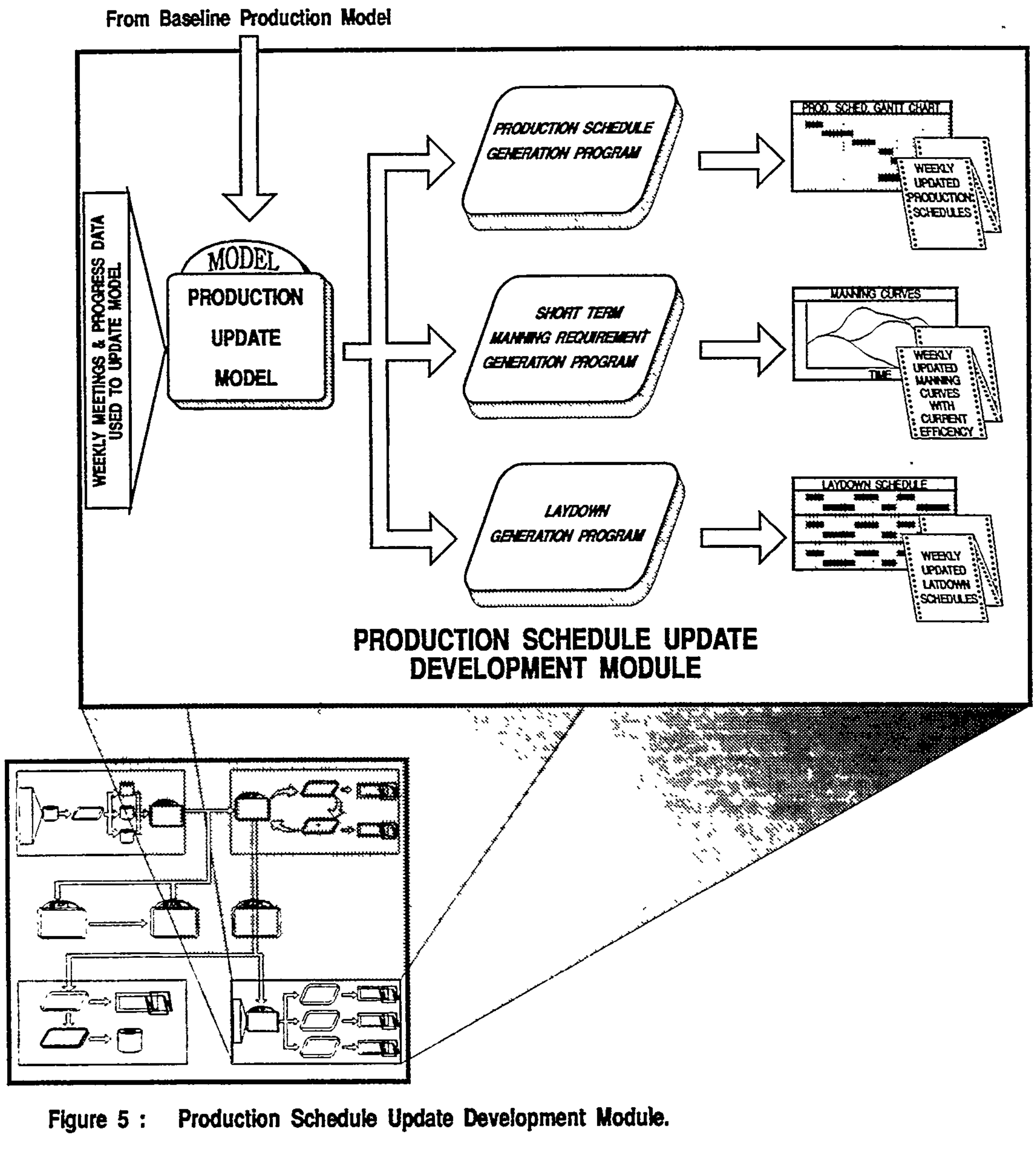


Figure 5 : Production Schedule Update Development Module.

SYSTEM COMPONENTS

As stated earlier, this presentation is only meant to report on the progress of the system to date. The Integrated Production Planning System is still in the process of development. A full report on the system will be available through the NSRP in early 1992. This full report will include hard copies, disk copies, and documentation of all programs written at NASSCO for this project. The report will also include information regarding how to obtain the commercially-available software discussed in de paper.

Open Plan™ Software

The Integrated Production Planning System is built around Welcom Software Technology's Open Plan™ PC-based project management software (hence referred to as the project management software). There are several PC-based project management packages on the market today. One of the advantages of this software is that the software package operates within a dBase™ shell. AU of the project management software input and output files are in standard dBase™ format. This allows all pre-processing and post-processing programs built around the project management software to be written in dBase™

All models shown in the System Overview exist within the project management software framework. The software serves to take data regarding individual activities and creates schedules and resource utilization files. The data regarding individual activities is placed into three separate files. The activity file contains the duration of each activity. Before this file is processed, the only dates in this file are the start or complete date for key events. The relationship file shows the required interaction between various activities. The resource file shows the manning and facility requirements of each activity; The project management software processes these data files and generates all the dates that were not previously defined. These dates are stored to the processed activity file. The software also creates a resource aggregation file. This file shows the utilization of all resources as a function of time. The major inputs and outputs of a project management software model are shown in figure 6.

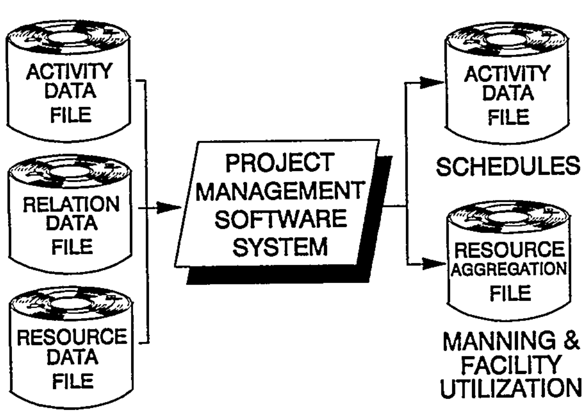


Figure 6 : Project Management Software Input and Output Files.

System Control Progam

All of the programs that interact to create the Integrated Production Planning System can be accessed through the System Control Program. As illustrated in figure 7, the program is menu driven and is used to guide the user into and out of the various system functions.

Model Builder Program

The Integrated Production Planning System models the activities associated with the assembly, outfitting, and erection of hull blocks. A scheduling model with sufficient detail to meet the system objectives will be large. A model for a 700' container ship consisted of 3000 activities, 3000 relationships, and 10,000 resource requirements. These numbers will vary depending upon the size and complexity of the vessel. A yardwide integrated planning model is too large to make practical the entering of all relevant data by hand. Using similarities that exist between groups of activities, relationships, and resources a program can be developed that builds a standard set back model for a ship. The Model Builder Program uses block specific data and build strategies by block type. Based on strategy sheet data, the Model Builder Program creates activity, resource, and relationship files in proper format to be used by the project management software.

Capacity Requirement Generation Program

Capacity requirements for each activity are included as a resource when the model is generated. The Capacity Requirement Generation Program uses the yardwide schedule development model's resource aggregation file (created by the project management software) to show resource utilization information in both graphical and tabular form. The resources may be shown singly or grouped according to WBS or OBS.

Long Range Manning Requirement Generation Program

Budgeted hours for each activity are included as resources when the model is generated. The Long Range Manning Requirement Generation Program uses the yardwide schedule development model's resource aggregation file (created by the project management software). The data from this file is combined with manning requirements from other areas of the yard not included in the Integrated Production Planning System to produce manning requirements in both graphical and tabular form. Depending upon how the resource requirement was initially entered into the system, the output may be shown by trade class, area, or any groupings of trade classes or areas. The program also allows for these requirements to be factored up or down to allow for actual production efficiencies.

Master Schedule Generation Program

The Master Schedule Generation Program uses the activity file of the baseline production model (after processing by the project management software). The program takes the activity file and extracts the dates necessary to generate the various master schedules used throughout the yard.

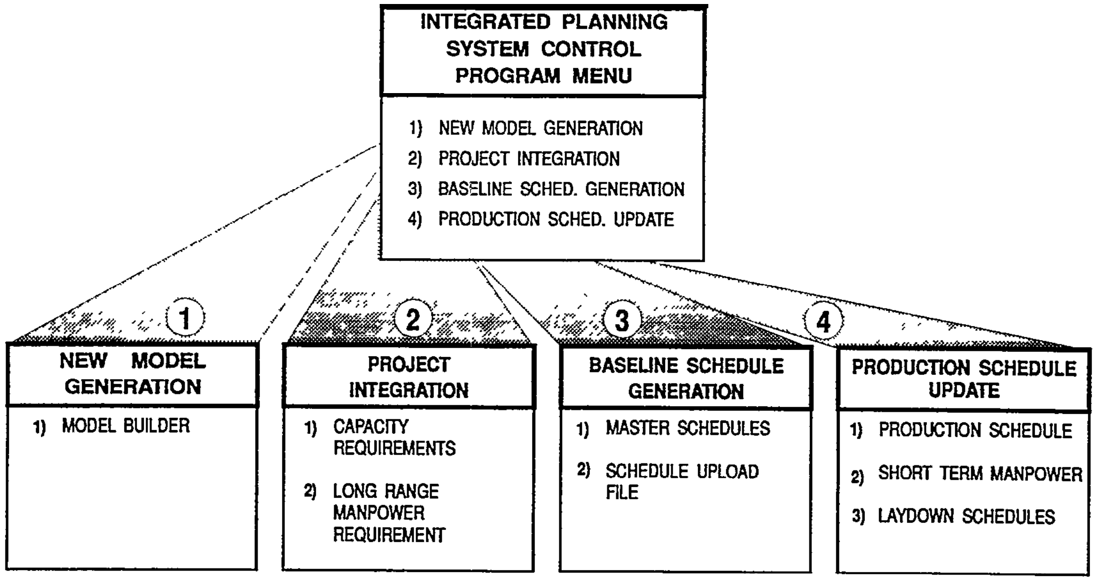


Figure 7 : System Control Program.

Master Schedule Upload File Generation Program

The Master Schedule Upload File Generation Program uses the data files created by the Master Schedule Generation Program. These files are converted to a form so that they may be uploaded into the schedule tracking system database. This allows the schedule tracking system to be rapidly and accurately updated when a change occurs to a master schedule.

Production Schedule Generation Program

The Production Schedule Generation Program uses the activity file of the production update model (after processing by the project management software). The program takes the activity file and extracts the dates necessary to generate the updated production schedules in both graphical and tabular form. These schedules show planned vs. actual dates and projected progress.

Short Term Manning Requirement Generation Program

The Short Term Manning Requirement Generation Program is similar to the Long Range Manning Requirement Generation Program. However, the short term requirements are generated from the resource aggregation file of the production update model rather then the yardwide schedule development model.

Laydown Generation Program

The Laydown Generation Program uses the activity file of the production update model (after processing by the project management software). The program takes the activity file and extracts the dates and laydown locations necessary to develop laydown schedules for each production area in both graphical and tabular form.

SYSTEM USAGE

To demonstrate how the Integrated Production Planning System is used, schedules were developed and progressed for a test case. The test case is the construction of the M/V Well Planned, a small, double-hulled product carrier. The first and most important task in scheduling is the development of a build strategy. The build strategy for the M/V Well Planned is expressed in terms of the documents described in the Systems Development Philosophy section of this report The strategy sheets for the M/V Well Planned are shown in figures 8 through 15.

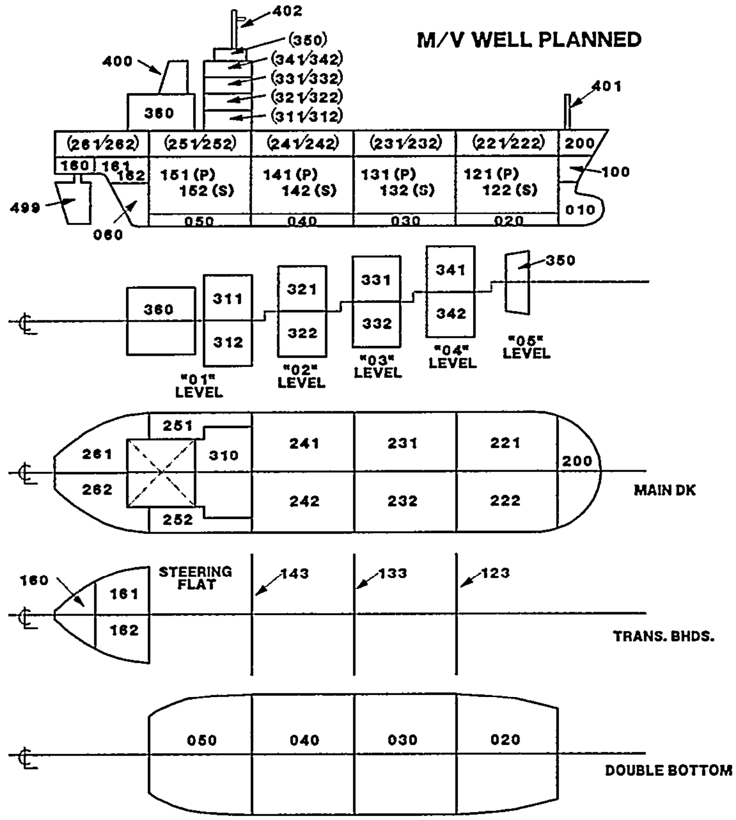
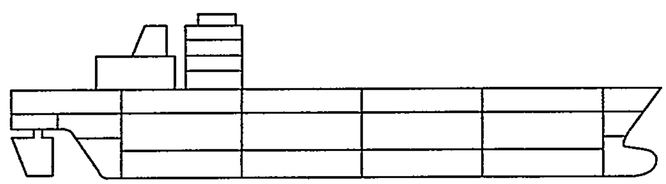


Figure 8 : Block breakdown of M/V WELL PLANNED.



BLK TYPE	BLOCK NUMBERS	BUILD STRAT.	ASSY	PRE-BLAST INVERTED	PRE-BLAST UP RIGHT	BLAST & PAINT	POST BLAST
DOUBLE BOTTOM	020,030 040,050	STANDARD	20 1500	–	5 250	5 100	5 250
TRANS. BHD.	123,133 143	STANDARD	15 500	5 150	–	5 100	5 150
STERN	160,261 262	STANDARD	15 200	10 300	5 150	5 100	5 150
STERN	161,162	GRAND BLK ASSEMLY	15 100	–	–	–	–
MAIN DECK	251,252	STANDARD	15 800	5 200	–	5 100	5 200
MAIN DECK	221–>242	GRAND BLK INVERTED	15 1000	–	–	–	–
WING	121–>152	STANDARD	15 800	5 150	–	5 100	5 150
BOW	200	STANDARD	20 1500	5 125	5 125	5 100	10 125
BOW	010,100	GRAND BLK UP RIGHT	20 2000	–	–	–	–
HOUSE	310–>350	GRAND BLK POST	15 800	20 800	5 200	5 100	–
MAST	401,402	SHOP	–	10 300	–	5 100	20 700
RUDDER	499	STANDARD	30 1000	–	–	5 100	–
CASTING	360	STANDARD	15 900	10 500	10 500	5 100	10 500
STACK	400	STANDARD	20 1000	–	10 500	5 100	10 500

Figure 9 : Durations and budgets by block type for M/V WELL PLANNED

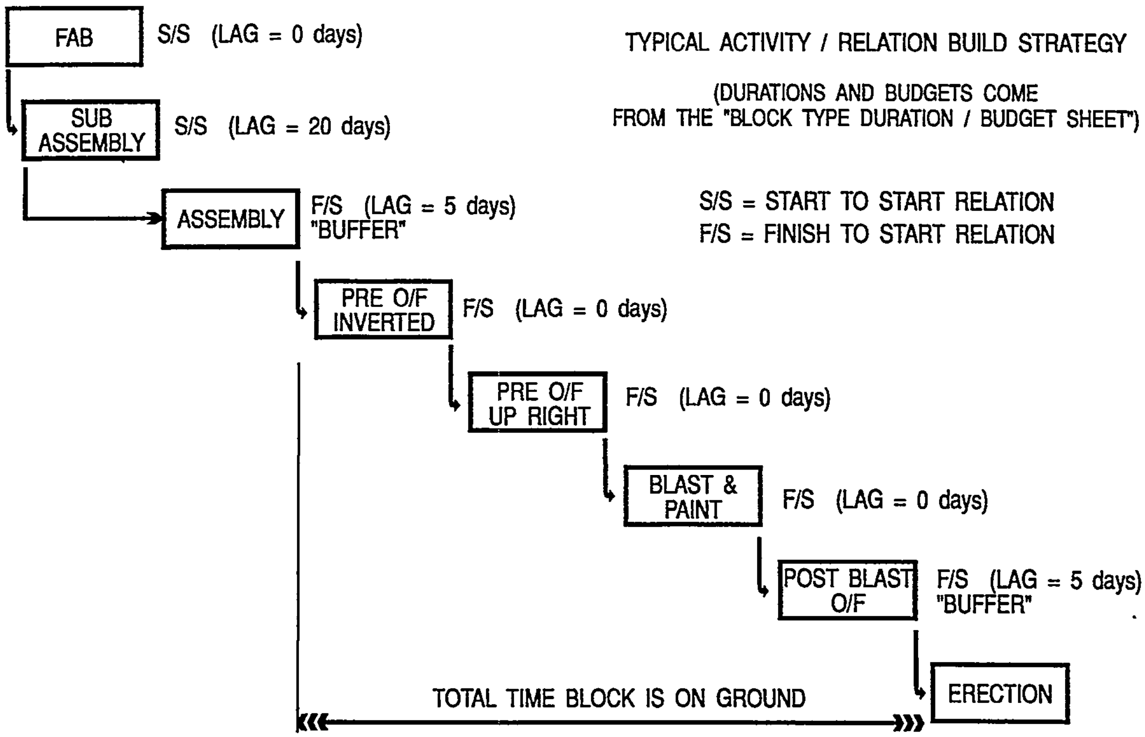


Figure 10 : Activities and relationships for a block with a "Standard" build stategy.

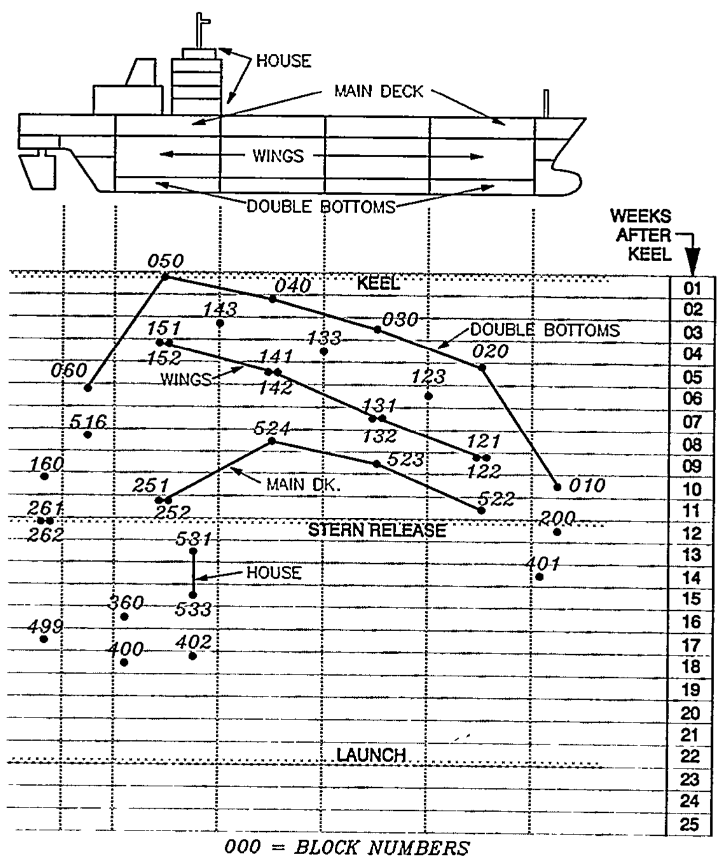


Figure 11 : Erection "star" chart for the M/V WELL PLANNED.

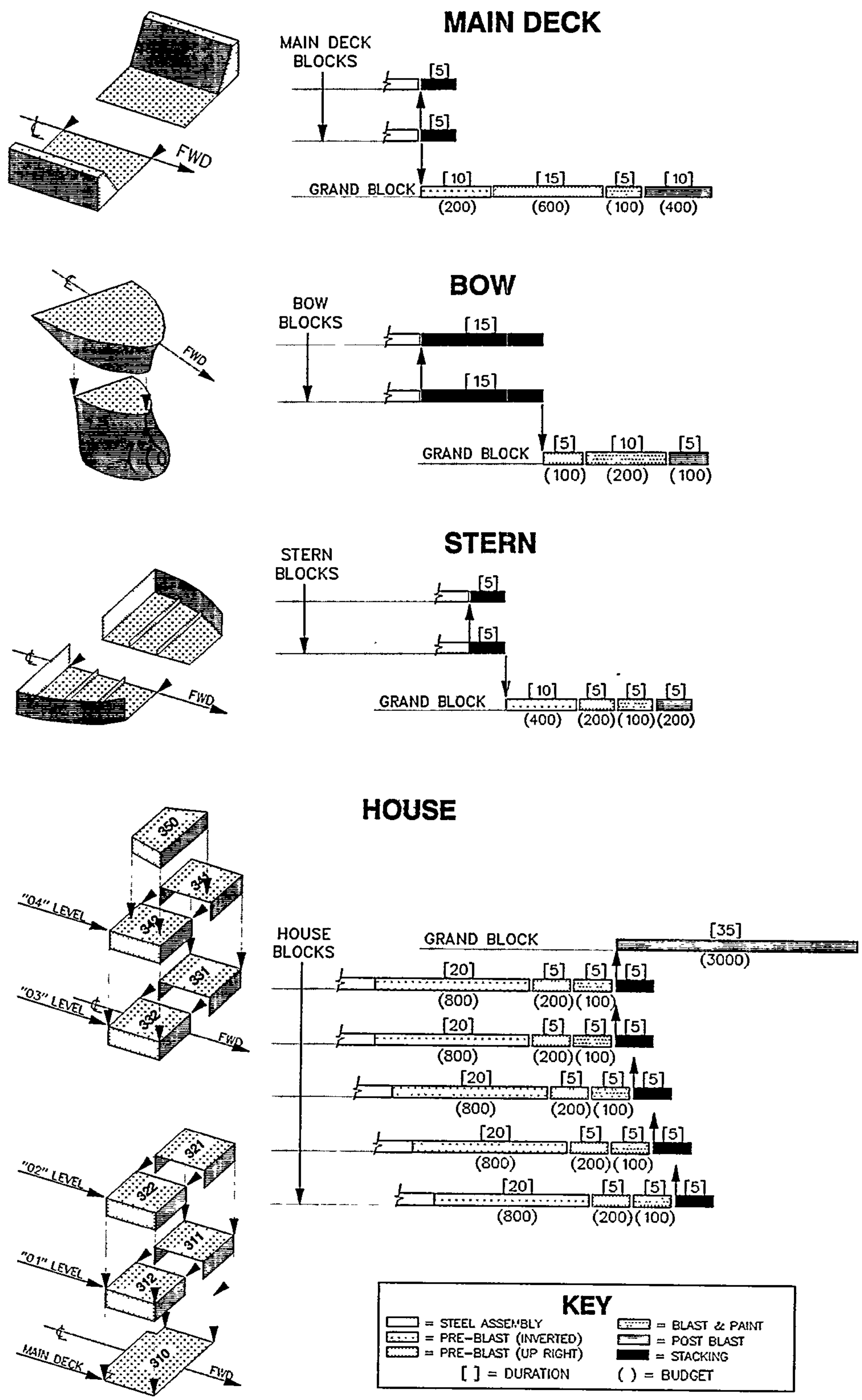


Figure 12: Grand block strategies for M/V WELL PLANNED.

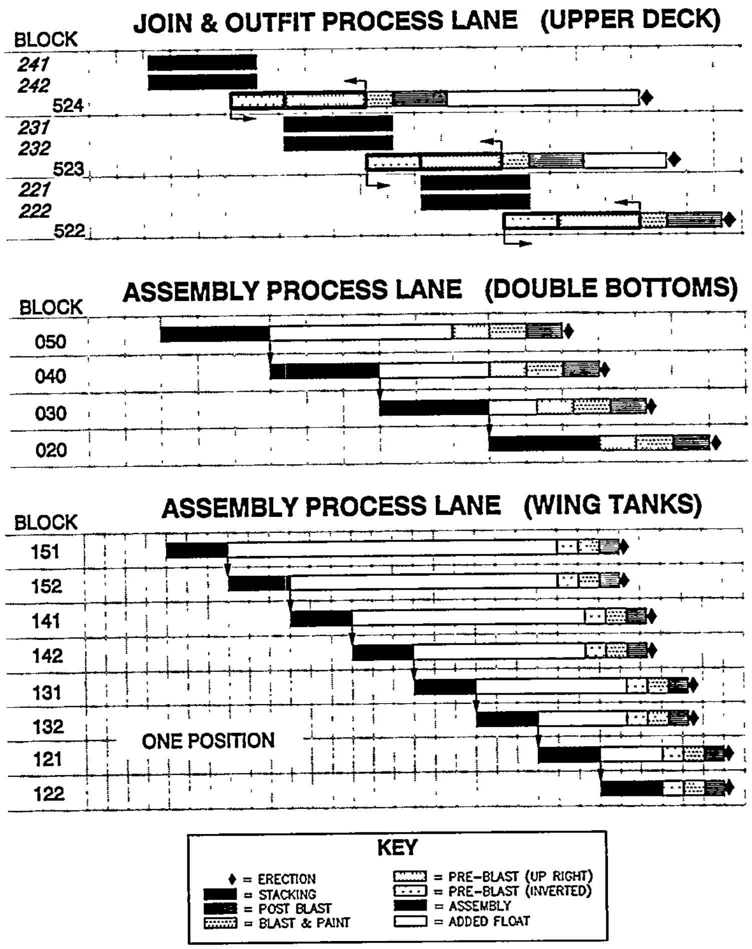


Figure 13: Process lane strategies type for M/V WELL PLANNED.

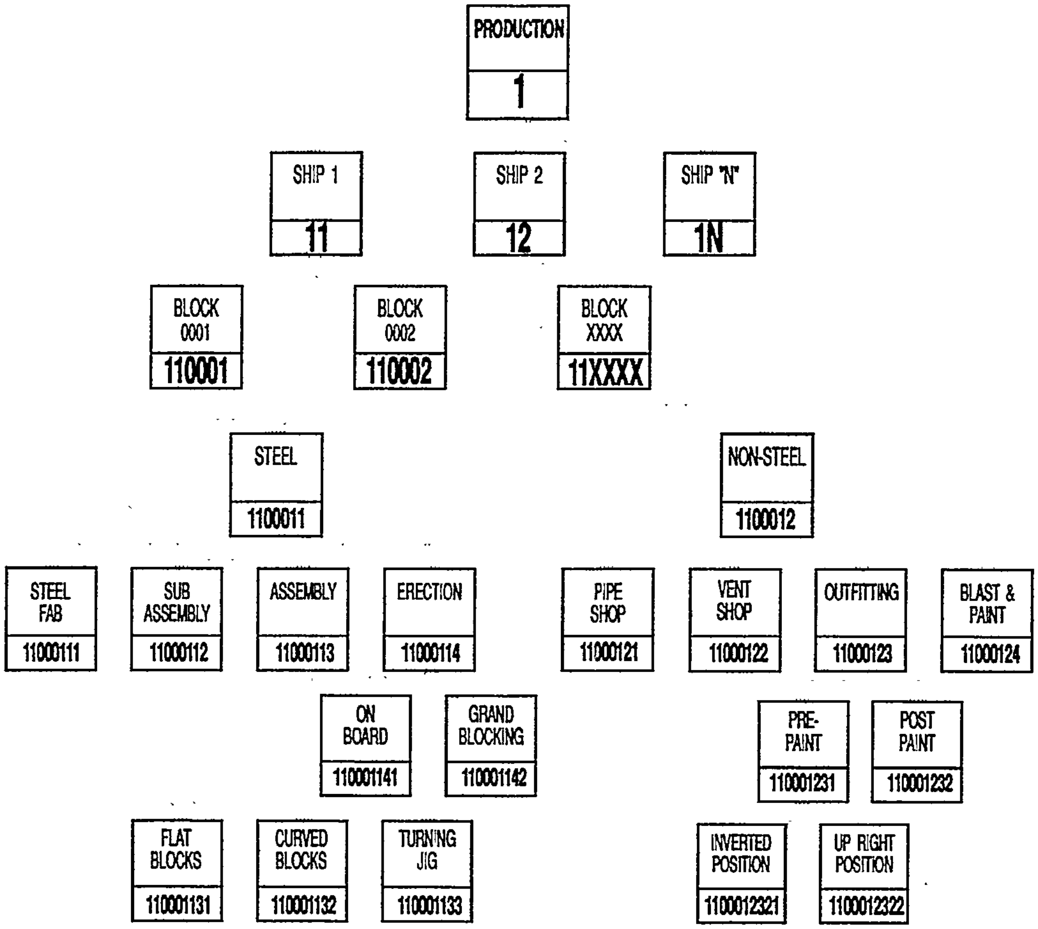


Figure 14 : Typical shipyard WBS.

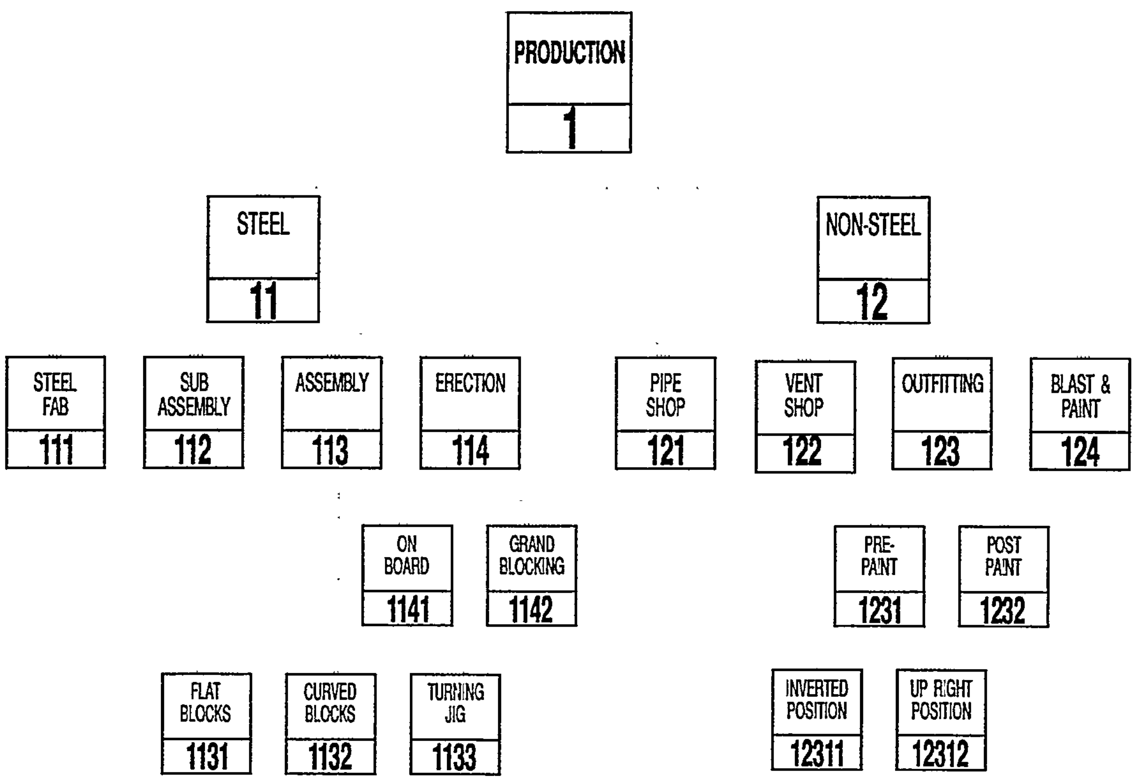


Figure 15 : Typical shipyard OBS

Information from de documents shown is used to create the M/V Well Planned's Ship Build Master Data File. This file is processed by the Model Builder Program to create a Standard Set Back Model for the ship. This model consists of the activities, resources, and relationships required to assemble and outfit the blocks in preparation for erection. The erection activity for each block is fixed to a particular date as defined by the strategy sheets. Since the final event in each chain of activities is locked, the entire network of activities can be back-scheduled to show the late start and complete dates for each activity in the network.

The standard setback model of the M/V Well Planned showed the required start of construction date for the vessel to be 22 weeks before keel. This is not acceptable. To alleviate this situation the build strategies must be altered. In the case of the M/V Well Planned start of construction is driven by the wing tank block assembly process lane. To solve this problem the strategy was altered by using a second build position for this process lane. The revised process lane strategy sheet to reflect this change is shown in figure 16. The model is altered to reflect this new strategy by updating the relationships between the wing tank block assembly activities. The model is then reprocessed. The start of construction date with this new strategy becomes 10 weeks before keel. The build strategy is now acceptable.

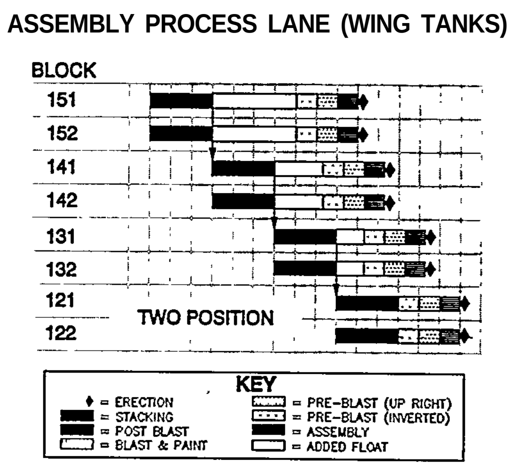


Figure 16 : Revised process lane strategy sheet.

The initial model is back-scheduled to late dates, therefore any leveling done is accomplished by moving activities earlier. Resource leveling strategies must reflect the constraints imposed by a particular yard's capabilities. If a yard has only a limited area to assemble the blocks, schedules may be leveled on blocks going through this particular area. If there is a required trade for which the yard has limited manning, schedules may be leveled based upon the trade's availability. Schedules may be leveled on any resource or combination of resources included within the model. Since the Integrated Production Planning System operates by back scheduling to late dates, the generalized resource leveling strategy is to first level resources in the area that immediately precedes the erection activity and then work back to earlier activities.

The strategy used for resource leveling of the M/V Well Planned is to first level the outfit area manning. Since resources are interchangeable between de pre-blast inverted, pre-bast upright, and post blast outfitting activities, these activities are grouped by their common OBS code and leveled together. Once the outfitting area is leveled the assembly area is investigated. The assembly area in this example is leveled based upon the number of blocks with work in progress in both the flat and curved block build areas. By leveling first the outfitting area manning and then the assembly area work in process, a feasible Master Production Schedule is created. This schedule reflects the build strategies for the vessel as well as taking into account the manning and facility availability.

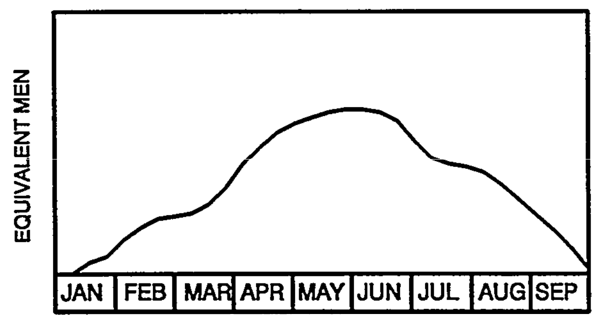


Figure 17: Outfit area manning requirements, iteration 1 - by standard setbacks.

Figure 17 shows the output of the long range manning requirement generation program for the outfit area. An analysis of the blocks outfitting during the peak months of April, May, and June show that the majority of the manning requirements during this period of time are driven by the outfitting of the house blocks and house grand blocks. In order to level manning in this area the outfitting of the lower house (grand block 531) will be scheduled prior to the outfitting of the upper house (grand block 533). To change the model to reflect this strategy a single relationship is added. The new relationship forces the outfitting of block 531 to complete before the outfitting of block 533 can start. Since the activities are linked, the system will reschedule the assembly, outfitting, and stacking activities of all blocks which comprise grand block 531. The results of this reschedule (iteration 2) are shown in figure 18.

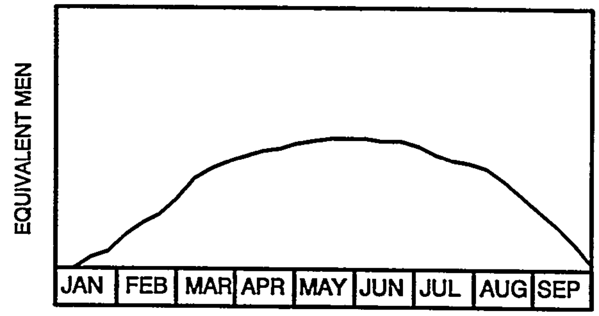


Figure 18: Outfit area manning requirements, iteration 2 - grand block 531 forced early.

The manning curve for the outfitting area is now acceptable. Next, an analysis is made of the facility utilization within the assembly area. Two independent resources must be investigated within the assembly area. Both the flat block build platen and the shaped block build platen have limited space. The MPS must be adjusted so as to level both of these resources. Since the resources are independent, they may be leveled simultaneously.

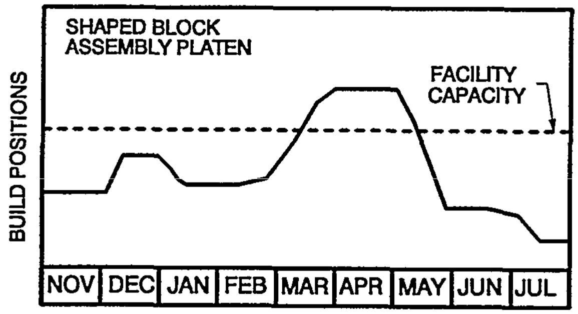


Figure 19: Shaped platen facility utilization based upon iteration 2 of the model.

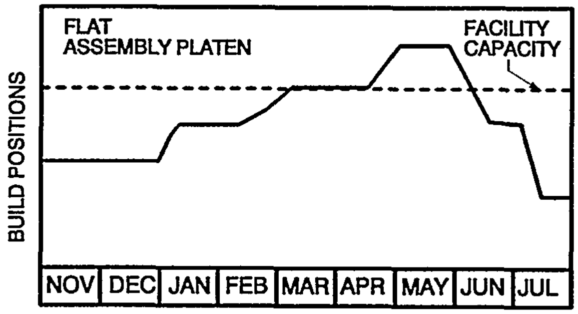


Figure 20: Flat platen facility utilization based upon iteration 2 of the model.

Figures 19 and 20 show the outputs of the capacity requirement generation program. Note that the system is back-scheduling to late dates and the assembly activity precedes the outfitting activities. Therefore, when assembly activities are forced earlier, float is introduced between the assembly and outfit operations. This has no impact on the outfitting area manning requirements. The resource leveling strategy for the M/V Well Planned makes no attempt to level the assembly area manning. However, there is a high correlation between assembly build positions in use and assembly area manning requirements. If assembly build position usage is level, assembly area manning requirements are also fairly level. To level the shaped block assembly platen, some of the blocks scheduled to assemble in April are rescheduled to assemble earlier to fill in the valley in the February-March time period. When leveling the flat block assembly platen it is not desirable to take the excessive work in May and reschedule it for February. This would break the logical build sequence for the ship. Instead, the schedule should be modified to push earlier the building of a few blocks in March, April, and May. This will eliminate the excessive capacity requirements while maintaining a proper build sequence. The results of this rescheduling (iteration 3) are shown in figure 21 and 22.

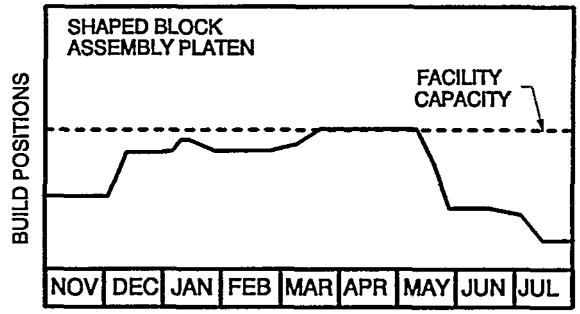


Figure 21: Shaped platen facility utilization based upon iteration 3 of the model.

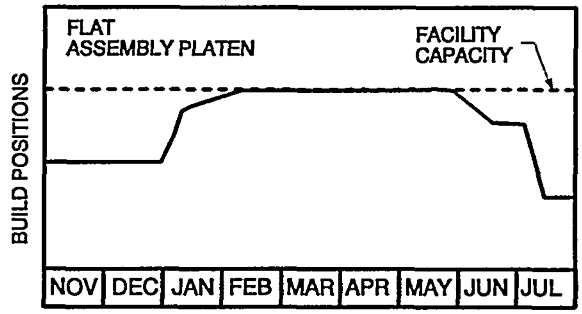


Figure 22: Flat platen facility utilization based upon iteration 3 of the model.

The facility utilization within the assembly area is now acceptable. This model is named the baseline production model and processed by the Master Schedule Generation Program to create a Master Production Schedule. The MPS is approved by production engineering, materials and support groups and the schedule is issued. An upload file is created to support the schedule tracking system

A copy of the baseline production schedule is renamed the production update model. This model is updated based upon weekly meeting and progress data. These weekly meetings are attended by members of the assembly, outfitting, and erection groups. These meetings serve to update the short term schedule documents based upon actual and projected progress. The steps in updating the short term production schedule are illustrated.

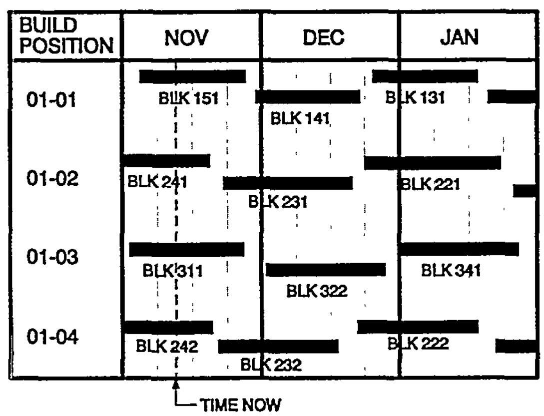


Figure 23: flat platen assembly laydown chart.

Figure 23 shows the current production schedule for the flat platen assembly area. At the production update meeting, the assembly area representative will report on actual and projected progress. The assembly area laydown chart is marked up by the assembly area representative as shown in figure 24. Based on the assembly area inputs, changes will be made to the production schedule. These changes are shown in table 2. The production update model is modified to reflect the actions taken in the meeting. The model is reprocessed. Updated production schedules are issued to appropriate groups.

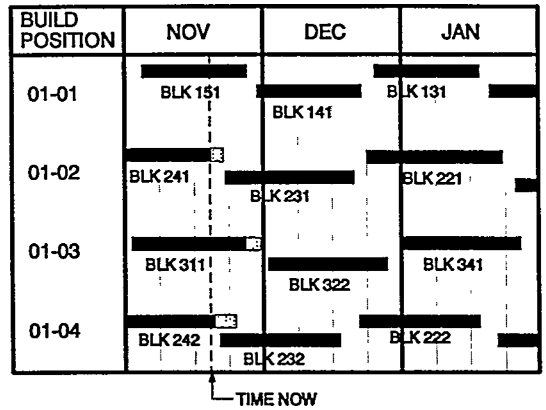


Figure 24: Flat platen assembly laydown chart as modified by the assembly area rep. at the production update meeting.

CONFLICT	ADJUSTMENT
BLOCK 242 IN BUILD POSITION I-4 WILL OVERLAP WITH LAYDOWN OF BLOCK 232.	ASSEMBLY AGREES TO CRASH THE DURATION OF BLOCK 232 IN ORDER TO RECOVER TO THE SCHEDULE.
THE EXTENDED DURATION OF BLOCK 311 IN BUILD POSITION 1-3 DOES NOT CAUSE A CONFLICT IN THE ASSEMBLY AREA. HOWEVER, THIS 3 DAY DELAY WILL CUT INTO THE SCHEDULED OUTFITTING DURATION.	OUTFITTING, MADE AWARE OF THE DELAY AND ITS IMPACT AHEAD OF TIME, AGREES TO WORK THIS BLOCK MORE AGGRESSIVELY TO MAKE UP FOR THE DECREASED DURATION.
THE EXTENDED DURATION OF BLOCK 241 IN BUILD POSITION 1-2 HAS NO IMPACT ON OTHER BLOCKS IN THE ASSEMBLY AREA. THERE IS FLOAT BETWEEN THIS ACTIVITY AND THE OUTFITTING ACTIVITIES OF THIS BLOCK	LATER ACTIVITIES ARE NOT AFFECTED, THEREFORE, THIS DELAY HAS NO IMPACT.

Table 2: Adjustments made to the production schedule.

CONCLUSION

An effective MPS must reflect a build strategy, material and engineering availability, and facility and manpower availability. A PC-based system can be established to assist in creating and updating the MPS. Such a system is currently being developed under NSRP task N8-91-6. When the full report is made available, it will be more detailed in its description of the production planning system. The final NSRP report will give recommendations on how the Integrated Production Planning System can be improved and expanded. The final report will also give guidelines and recommendations as to how to adopt this system for use in other shipyards.

REFERENCES

1. APICS Dictionary, 5th ed., T.F. Wallace, Ed., American Production and Inventory Control Society, Falls Church, Va. 1984.

2. Production Planning and Inventory Control, D. McLeavey and S. Narasimhan, Allyn and Bacon, Inc. Newton, Mass, 1985.

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